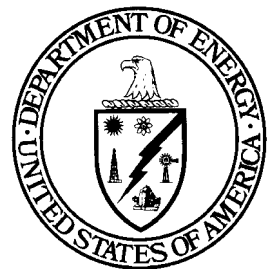


Concrete Dust Suppression System

**Deactivation and Decommissioning
Focus Area**



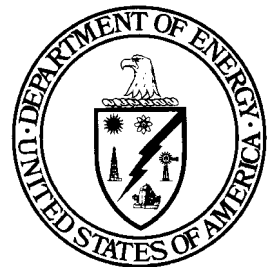
Prepared for
U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

December 1998

Concrete Dust Suppression System

OST Reference # 2154

**Deactivation and Decommissioning
Focus Area**



Demonstrated at
Hanford Site
Richland, Washington



Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at <http://OST.em.doe.gov> under "Publications."

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SECTION 1

SUMMARY

The improved technology is a water-based dust suppression system for controlling concrete dust generated by demolition equipment, in this case a demolition ram. This demonstration was performed to assess the effectiveness of this system to 1) minimize the amount of water used to suppress potentially contaminated dust, 2) focus the water spray on the dust-generating source and 3) minimize the dust cloud generated by the demolition activity. The technology successfully reduced the water required by a factor of eight compared to the traditional (baseline) method, controlled the dust generated, and permitted a reduction in the work force. The water spray can be focused at the ram point, but it is affected by wind. Prior to the use of this dust control system, dust generated by the demolition ram was controlled manually by spraying with fire hoses (the baseline technology). The improved technology is 18% less expensive than the baseline technology for the conditions and parameters of this demonstration, however, the automated system can save up to 80% versus the baseline whenever waste water treatment costs are considered. For demolishing one high-walled room and a long slab with a total of 413 m³ (14,580 ft³) of concrete, the savings are \$105,000 (waste water treatment included). The improved technology reduced the need for water consumption and treatment by about 88%, which results in most of the savings.

■ Technology Summary

On March 18, 1998 the Hanford Site C Reactor Technology Demonstration Group demonstrated a water-based dust suppression system for controlling concrete dust generated by a demolition ram (Model 375 Caterpillar excavator fitted with a hoe-ram). This improved technology was demonstrated for the U.S. Department of Energy's (DOE) C Reactor Interim Safe Storage (ISS) Project as part of the Large-Scale Demonstration and Deployment Project (LSDDP) at DOE's Hanford Site in Richland, Washington.

The dust suppression system is an attractive alternative to traditional methods of controlling dust, which involve spraying water with a manned fire hose. The improved system is mounted on an excavator fitted with a hoe-ram and consists of a water tank, pump, spray nozzles, and controls.



**Hoe-ram with water sprays
demolishing a high-wall.**



Water tank with pump mounted on excavator.

The entire dust suppression system is built from off-the-shelf commercially available parts except for the skid framework, which was custom fabricated. Dust suppression water in a 2,044-liter (540-gallon) water tank is replenished through a fire hose with a quick-disconnect fitting mounted on the tank supply pipe. The connection must be made every time the tank requires refilling. The water supply tank may require refilling several times daily, depending on the demands of dust control.



The technology can be used to control dust while demolishing concrete floors, walls, and other surfaces, both interior and exterior, with heavy-duty rams, shears and grapples, and for excavating soil.

Problem Addressed

The DOE is in the process of decontaminating and decommissioning (D&D) many of its nuclear facilities throughout the nation. Typically, the facilities undergoing D&D are contaminated, either chemically or radiologically, or both. The dust generated by demolition equipment must be controlled for both worker health and contamination control. With the installation of this improved technology, the water spray is focused toward the demolition ram point where the dust is generated. Prior to the installation of the technology, ram-generated dust was controlled manually with a water spray from a fire hose, creating a large amount of contaminated wastewater that may need collection, treatment, and disposal.

Features and Configuration

- 2,044-liter (540-gallon) plastic water tank and a 6-kW (8-hp), 40-bar (580-psi) water pump.
- Excavator-operated on - off switches
- 8 full jet spray nozzles (Spraying Systems Co. Model number G30-SS-3007)
- Focused water spray

Potential Markets/Applicability

The spray system can be installed on dust-generating demolition and excavating equipment at DOE, U.S. Environmental Protection Agency (EPA), or U.S. Nuclear Regulatory Commission (NRC) sites where dust suppression is required to eliminate the spread of contamination and where secondary contamination must be kept at a minimum. The technology could be used at other public or commercial facilities with similar needs for dust suppression.

Advantages of the Improved Technology

The following table summarizes the advantages and disadvantages of the improved technology against the baseline (traditional) technology in key areas:

Category	Comment
Cost	The improved technology costs 18% less labor than the baseline technology. With a reduction of almost 90% in water use and runoff, considerable additional savings will accrue at contaminated sites.
Performance	Dust control is attained (when wind speeds are low) and wastewater runoff and treatment are reduced.
Implementation	The system is easily installed by plant maintenance forces.
Secondary Waste	Wastewater is reduced by almost 90% in comparison to the baseline.
ALARA/Safety	Use of the dust suppression system supports the ALARA principle and eliminates the operation of one scissor lift and fire hose operators.
Ease of Use	The system has simple on-off controls in the excavator cab.



Operator Concerns

The ram operator's ability to see the ram point penetrating the wall is limited by the water spray and the ability to focus the water spray is affected by windy conditions, both more so than with the baseline technology.

Skills and Training

No significant training of the excavator/hoe ram operator is required.

■ Demonstration Summary

The improved dust suppression system was demonstrated March through June 1998 by the Hanford Site C Reactor Technology Demonstration Group.

Demonstration Site Description

At its former weapons production sites, DOE is conducting an evaluation of improved technologies that might prove valuable for facility D&D projects. DOE's Office of Science & Technology/Deactivation and Decommissioning Focus Area, in collaboration with the Environmental Restoration Program, is undertaking a major effort of demonstrating improved technologies at its sites nationwide. If successfully demonstrated at the Hanford Site, these improved technologies could be implemented at other DOE sites and similar government or commercial facilities.

The dust suppression system was demonstrated for the first time at the DOE's Hanford Site. Dust was controlled while demolishing high, reinforced concrete walls and on flat concrete slabs and low walls.

Key Demonstration Results

- The amount of dust suppression water used (and thus the potential for spreading contamination) was reduced with the improved technology by a factor of 8 over the baseline for concrete floor slabs and low walls: 16 liters water/m³ of concrete demolished versus 128 liters water/m³ (0.12 gallons water/ft³ versus 1 gallon water/ft³). For high vertical walls, the amount of water was reduced by a factor of 8.3 over the baseline: 230 liters water/m³ of concrete demolished versus 1,900 liters water/m³ (1.7 gallons water/ft³ versus 14 gallons water/ft³).
- Equipment required for dust control on high walls was reduced by the elimination of one manned scissor lift for D&D workers to spray water on the dust generated by the hoe ram.
- For concrete slabs and low walls, the number of D&D workers was reduced from one full-time D&D worker to a one-quarter-time D&D worker. For high walls, the number of D&D workers required for the baseline test was two to four; with the improved dust control system the number was reduced to 1.75 D&D workers.
- The system is now installed and provides effective dust control for ongoing demolition work.

Regulatory Issues

There are no special regulatory or permit requirements associated with implementation of this technology. Normal worker safety practices should be applied when using this tool in accordance with applicable regulations, particularly 10 *Code of Federal Regulation* (CFR), Parts 20, 835, and proposed Part 834, for protection of workers and the environment from radiological contaminants; and 29 CFR Occupational Safety and Health Administration (OSHA) worker requirements.



Technology Availability

The dust control system demonstrated at the Hanford Site C Reactor can be readily fabricated at most local welding shops, in this case by Rowand Machinery, Pasco, Washington.

Technology Limitations/Needs for Future Development

While the improved technology provides acceptable dust control, wind in the demolition area blows water spray away from the dust-generating source more than with baseline firehoses.

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Others

All published Innovative Technology Summary Reports are available at <http://em-50.em.doe.gov>. The Technology Management System, also available through the EM50 Web site, provides information about OST programs, technologies, and problems. The OST Reference Number for Concrete Dust Suppression System 2154.



SECTION 2

TECHNOLOGY DESCRIPTION

Overall Technology/Process Definition

The DOE nuclear facility D&D program strives to use the best technologies on the market today for D&D activities nationwide. Minimizing and controlling waste generation is an important goal of the D&D program. The improved concrete dust suppression system developed for the Hanford Site C Reactor D&D project was demonstrated with a hoe-ram used routinely to demolish thick concrete structures. The hoe-ram operator can switch water on and off that is pumped to spray nozzles mounted near the end of the boom that holds the ram.

Components

Materials and parts are all standard off-the-shelf equipment. The spray nozzles are manufactured from 304 stainless steel. The dust suppression system is mounted on a caterpillar 375 excavator fitted with a hoe-ram and consists of the following components:

- 2,044-liter (540-gallon) plastic water tank
- 6-kW (8-hp), 40-bar (580-psi), gasoline-powered constant-pressure pump with an electric starter and battery
- Custom-fabricated skid for mounting the tank and pump that is installed on the back of the excavator
- Electric foot- and hand-operated switches for the excavator operator to turn the water spray manifold valve open and closed
- U-shaped heavy-duty spray nozzle protection assembly fabricated from 7.6-cm x 15.2-cm (3-in. x 6-in.) steel tube, mounted 1.5 m (5 ft) back from the ram point
- Spray nozzle manifold mounted within the protection assembly
- 8 fulljet spray nozzles (Spraying Systems Co. Model No. G30-SS-3007)
- Pressure supply hose, connecting the pump and spray nozzle manifold
- Water tank fill pipe with a quick disconnect.

Figure 1 shows the skid about to be set in place on the excavator. Figure 2 shows the spray nozzle protection assembly about to be lowered into place.



Figure 1. Skid being mounted.



Figure 2. Protection assembly for spray manifold.

Overview

The dust suppression system built by Rowand Machinery (Pasco, Washington) and installed on a Caterpillar 375 excavator hoe ram controls the spread of concrete dust during demolition. Water spray nozzles are mounted on the hoe ram 1.5 m (5 ft) back from the ram point. Having the spray nozzles as close as possible to the dust generating source provides optimum control of dust. (However, the spray nozzles must be mounted back far enough so that they are not damaged as the ram enters and withdraws from concrete structures.) The 30-degree cone water spray pattern developed by the nozzles selected provides good control of dust emissions. A water supply tank and pump are mounted on a skid located on the back of the excavator. This improved dust control system can be installed on various types of dust-generating demolition and excavation equipment used in DOE facilities.

Secondary waste generated by the dust suppression system is far less than the waste generated by the baseline manually operated fire hose, which delivers 475 liters (125 gallons) per minute on the dust source. The new dust suppression system delivers water at the dust source at 12% of that rate. Most of the water either evaporates or effectively mixes with the concrete dust and settles on the ground.

■ System Operation

Setup

A D&D worker ensures the dust suppression water tank is filled every day and again as needed. A preoperational check is made and spray nozzles are tightened.

Operation

The hoe-ram is operated hydraulically and intermittently as the excavator is positioned and re-positioned. When dust suppression is required, the excavator operator switches on the gasoline-powered water pump from his cab to pressurize the system but without spraying water. From a selector switch, the operator can then activate spraying by selecting manual operation or alternatively automatic operation coincident with activation of the hydraulic-ram foot pedal. By activating the spray nozzles, a water mist is directly sprayed at the ram point where the dust is generated as the ram point penetrates concrete. The water mist is delivered on the dust source from eight spray nozzles at a rate of 57.5 liters per minute at 20.7 bars (15.2 gallons per minute at 300 psig).

There is no special training required for the operation of the dust control system. The excavator operator turns on the spray nozzles as dust control is needed. This does not interfere with the operator's control of the ram, because the operator can choose to activate automatic spray action. The operator does not have to depend on and communicate with other workers manning fire hoses to turn water spraying on and off. Maintenance of the system is minor and does not require any special training.



SECTION 3

PERFORMANCE

■ Demonstration Plan

The demonstration was conducted at the C Reactor building at DOE's Hanford Site. One purpose of the LSDDP is to demonstrate and document performance data and costs for improved and innovative technologies that can aid in placing the C Reactor into an interim storage mode for up to 75 years, or until the final disposal of the reactor's core is completed. The C Reactor ISS objectives include: reduce or freeze future decommissioning costs, minimize releases to the environment, and reduce the frequency of inspections and potential risk to workers.

The DOE is in the process of decontaminating and decommissioning many of its nuclear facilities throughout the country. Facilities have to be dismantled and demolition waste must be sized into manageable pieces for handling and disposal. The secondary waste generated as a result of this decommissioning activity must be kept at a minimum. At C Reactor, concrete dust generated during demolition activities has always been controlled by spraying with water, using equipment and labor resources and generating secondary waste in the form of wastewater runoff. As a result of the successes this demonstration, the improved dust suppression system is now routinely used at C Reactor during concrete demolition activities, using less labor and generating less wastewater runoff.

Site Description

The demonstration was done with the demolition of a 12.2-m-high x 0.9-m-thick x 30-m-long (40-ft x 3-ft x 100-ft) outer rod room wall and a 9.1-m high x 0.2-m-thick x 39.3-m-long (30-ft x 8-inch x 129-ft) water-tunnel roof slab at grade. The wall was contaminated on one side that had been sprayed with fixative paint prior to being demolished. The slab was not contaminated.

At the C Reactor area wastewater runoff is either captured at a lift station and recovered for treatment or is allowed to soak into shallow soil. At the end of the C Reactor D&D, a layer of soil will be removed and disposed as LLW.

Performance Objectives

The objectives of the dust control system include the following:

- Reduce the amount of water required for effective dust control
- Reduce the use of scissor lifts and fire hoses traditionally used for dust control
- Reduce the potential of spreading contamination
- Reduce labor costs by having fewer D&D workers required for dust control
- Improved ALARA and safety by having less worker exposure at elevated levels.

Demonstration Chronology

The improved dust suppression system described in Section 2 was assessed against the baseline technology at the C Reactor building complex during March - June 1998 by the Hanford Site C Reactor Technology Demonstration Group.

The baseline technology for controlling concrete dust while demolishing high (over 3.7 m or 12 ft) walls is spraying of water from fire hoses by personnel stationed in two scissor lifts. For low walls and horizontal slabs at grade a worker sprays water from a hose pressurized by a gasoline-powered pump mounted on a truck with a water tank. The baseline and the improved technologies were each applied intermittently during the same months during demolishment of the outer rod room wall and the water-tunnel roof slab.



■ Technology Demonstration Results

The amount of water needed for adequate dust control with either the improved or baseline technologies depends on whether it is applied to a slab at grade or to a high wall. Low walls up to 3.7 m (12 ft) are treated the same as slabs.

Key Demonstration Results

The dust suppression system was successfully demonstrated and placed into operation at the C Reactor with the following results:

- The amount of dust suppression water used (and thus the potential for spreading contamination) was reduced with the improved technology by a factor of 8 compared to the baseline for concrete slabs and low walls: 16 liters water/m³ of concrete demolished versus 128 liters water/m³ (0.12 gallons water/ft³ versus 1 gallon water/ft³). For high (over 3.7 m) walls, the amount of water used was reduced by a factor of 8.3 compared to the baseline: 230 liters water/m³ concrete versus 1,900 liters water/m³ (1.7 gallons water/ft³ versus 14 gallons water/ft³). The results are based on water sprays being on 20% of the demolition activity time for slabs and 50% for high walls. (The sprays are switched off during intervals when the excavator is being repositioned or whenever the ram is withdrawn for a significant amount of time.)
- Equipment required for dust control on high walls was reduced by the elimination of one scissor lift for D&D workers to spray water from a fire hose.
- For concrete slab dust control, the number of D&D workers was reduced from one full-time D&D worker to a one-quarter-time D&D worker. On vertical walls, the number of D&D workers required for the baseline test was two to four; with the improved dust control system the number was reduced to one full-time D&D worker.
- The effective delivery of the water spray is affected by the force of the wind.
- The water mist directed at the ram point limits the ram operator's visibility of the ram point penetrating the concrete, but not enough to significantly affect the efficiency or safety of ramming operations.

Successes

- Large reduction in the amount of water used and wastewater needing treatment
- Reduction in labor required
- Easy operation
- Acceptable control of dust and of potential spread of airborne contamination.

Shortfalls

- The ram operator's ability to see the ram point penetrating the wall is limited by the water spray, more so than with the baseline fire hose sprays.
- The ability to focus the water spray is affected by windy conditions more than with the baseline.
- The fittings on the spray nozzles must be checked at the start of each day for tightness.

Meeting Performance Objectives

The objectives listed in the Demonstration Overview Section were met. The system is now installed and provides effective dust control for ongoing demolition work.



■ Comparison of Improved Technology to Baseline
Table 1. Summary of advantages of improved dust suppression system

Category	<u>Improved Technology</u> Automated Pressure/Nozzle Spray System	<u>Baseline</u> Fire Hose Water Application
Performance <ul style="list-style-type: none"> • Suppression • Visibility • ALARA/Safety 	Acceptable ⁽¹⁾ Acceptable, but not as good as baseline Better - less worker exposure at heights	Adequate and somewhat less susceptible to wind Acceptable Acceptable
Water Consumption	57.5 liters/min. @ 21 bars (15 gpm @ 300 psig)	475 liters @ 5.2 bars (125 gpm @ 75 psig) ⁽²⁾
Secondary Waste Generation (Concrete Floor Slab)	16 liters water/m ³ concrete (0.12 gallons water/ft ³)	128 liters water/m ³ concrete (1 gallon water/ft ³)
Secondary Waste Generation (Concrete High Wall)	230 liters water/m ³ concrete (1.7 gallons water/ft ³)	1,900 liters water/m ³ concrete (14 gallons water/ft ³)
D&D Workers, Concrete Slab Demolition	0.25 D&D worker	One full-time D&D worker
D&D Workers, Concrete High Wall Demolition	1.75 D&D workers	Two to four full-time D&D workers
Implementation	The system is easily installed by plant maintenance forces	Need a reliable source of pressurized water at high volumetric flow rate
Ease of Use	The system has simple on-off controls in the excavator cab	Easy to use, but need manlifts for high walls
Durability	Spray nozzles require replacement and pump engine requires overhaul at times during the system lifetime	No significant durability problems

Notes:

1. Dust suppression with the improved system is good when wind speeds are low.
2. Information obtained from the Hanford Fire Department.

Because of the variety of functions and facilities, the DOE complex presents a wide range of D&D working conditions. The working conditions for an individual job directly affect the manner in which D&D work is performed. The improved and baseline technologies presented in this report are based upon a specific set of conditions and/or work practices found at the Hanford Site and are listed in Table 2. This table is intended to help the potential technology user identify work item differences between improved and baseline technologies.

Table 2. Summary of Variable Conditions

Variable	Improved	Baseline
Scope of Work		
Quantity and Type	Dust suppression for demolition of 14,580 ft ³ of concrete (12,000 ft ³ of high wall and 2,580 ft ³ of slab at grade).	Same
Location	Hanford C Reactor	Same
Nature of Work	Control dust generated by hoe-ram during concrete demolition.	Same
Work Environment		
Worker Protection	Level D PPE	Same
Level of Contamination	None	Same
Work Performance		
Acquisition Means	Site workers and equipment	Same
Production Rates: <ul style="list-style-type: none"> Concrete Demolition Water Usage <ul style="list-style-type: none"> High Walls Slab 	8.75 m ³ /hr (309.5 ft ³ /hr) average 230 L/m ³ concrete (1.72 gal/ft ³) 16 L/m ³ concrete (0.12 gal/ft ³)	Same 1900 L/m ³ concrete (14.2 gal/ft ³) 128 L/m ³ concrete (1 gal/ft ³)
Equipment and Crew*	One scissor lift with plexiglass shield, one excavator with hoe-ram, one fire hose, one dust suppression system, two D&D workers, one heavy equipment operator, and one radiation control technician.	Two scissor lifts with plexiglass shields, one excavator with hoe-ram, two fire hoses, one flat bed truck, one skid mounted water tank, three D&D workers, one heavy equipment operator, and one radiation control technician.
Work Process Steps	1) Mobilize equipment 2) Safety meeting 3) Donn and doff PPE if needed	1) Mobilize equipment 2) Safety meeting 3) Donn and doff PPE if needed 4) Connect and run hoses

*The equipment and crew shown are for demolishing a high wall. For a low wall or a slab at grade, no scissor lifts are needed; the baseline crew is one D&D worker, one heavy equipment operator and one RCT; and the crew needed for the improved system is the same except only 0.25 D&D worker is involved.

Skills and Training

Training is not required; the excavator operator need only become familiar with the on-off switches. The excavator operator has the option to place the dust suppression system in either automatic or manual mode.

Operational Concerns

The effectiveness of the water-mist spray on the dust for dust control is reduced as the wind speed in the surrounding area increases. In addition, the water spray directed on the dust limits the operator's ability to see the ram point penetrating the wall, but not enough to significantly affect safe and efficient ram operations.

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVE TECHNOLOGIES

■ Technology Applicability

- The dust suppression technology can be used on rams for effective dust control when demolishing both contaminated and uncontaminated concrete structures at the Hanford Site, other DOE sites, and commercial plants undergoing D&D.
- With slight modifications, the dust suppression system can be fitted to other demolition and excavation equipment such as shears and backhoes, for both contaminated and uncontaminated structures and soil.

■ Competing Technologies

Vendor brochures (e.g., Tamrock, Atlanta, GA) indicate that ram manufacturers are marketing systems with a spray nozzle system built within the ram body.

■ Patents/Commercialization/Sponsors

- There are no known patents for this improved dust suppression technology.
- The dust suppression system demonstrated and operational at the Hanford Site is available from Rowand Machinery Co., Pasco, Washington, and could be fabricated at most welding shops anywhere.



SECTION 5

COST

■ Introduction/Methodology

This section provides a cost effectiveness analysis that compares the improved and baseline technologies used to control concrete dust generated by a demolition activity at the Hanford C Reactor. This analysis determined the improved technology is 531% less expensive than the baseline technology for the conditions and quantities of this demonstration. The improved technology is less expensive because of less wastewater needing treatment and the improved technology requires less D&D workers to operate the dust suppression system during concrete demolition.

The cost analysis assumes site ownership of the equipment and site labor. The cost effectiveness estimate is based on demolition of a concrete wall and a concrete slab (a water-tunnel roof) totaling 413 m³ (14,580 ft³) of concrete. The baseline costs are based on the same quantity of concrete but use two conventional fire hoses aiming the water stream at the dust generating source. Both the improved and baseline technologies use an excavator fitted with a hoe-ram for the demolition activity. The improved and baseline costs use the same production rates of 0.13 m³/minute (4.4 ft³/minute) for demolishing a concrete wall and 0.74 m³/minute (26 ft³/minute) for the underground water-tunnel roof slab at grade. These rates were determined from the demonstration. The cost effectiveness analysis includes fabrication of the improved technology equipment, site assembly, demolition activity, and water usage.

■ Cost Analysis

The dust suppression technology uses commercially fabricated equipment that is assembled on site. This equipment is outfitted with a 2044-liter (540-gallon) water tank and an 6-kW (8-hp) gasoline-powered pump. The assembled equipment is then mounted on a Caterpillar 375 excavator fitted with a hoe-ram. The total cost is \$25,372 (plus the procurement adder) and the corresponding equipment cost with the acquisition costs amortized over 7 years is \$9.90 per hour. Included in the total cost are the labor and equipment for field assembly of the system, which are \$6,075 and \$1,882, respectively. An annual repair cost of \$100 per year is included in the equipment hourly rate.

As indicated in the tables in Appendix B, the costs at C Reactor for demolishing a 12-m (40-ft) high set of walls 30.5 m (100 ft) long at the outer rod room and a 393-m (129-ft) long slab are shown in Table 3. Table 3 costs include capture/ treatment of runoff water for both the improved or baseline technology; however, this was not a necessary activity at the C-Reactor demonstration project.

Table 3. Overall cost comparison

	Volume of Concrete Demolished		Improved Technology	Baseline
High Walls	340 m ³	(12,000 ft ³)	\$23,931	\$127,949
Slab at Grade	73 m ³	(2,580 ft ³)	793	\$2,413
Totals	413 m ³	(14,580 ft ³)	\$24,724	\$130,362

Observed unit costs and production rates for principal components of the demonstrations for both the improved and baseline technologies are presented in Table 4. As detailed in Appendix B, Table 4 accounts for amortization and repair of the innovative dust suppression system, labor and equipment use, and water consumption costs.



Table 4. Summary of production rates, water usage and unit costs

Cost Element	Improved		Baseline	
	Production Rate and Water use	Unit Cost	Production Rate and Water use	Unit Cost
Demolition Operation				
• High Wall	8.75 m ³ concrete/hr (310 ft ³ /hr)	\$23.31/m ³ concrete (\$.66 ft ³)	8.75 m ³ concrete/hr (310 ft ³ /hr)	\$27.90/m ³ concrete (\$.79/ft ³)
• Slab at grade	44.2 m ³ concrete/hr (1560 ft ³ /hr)	\$3.58/m ³ concrete (\$.10 ft ³)	44.2 m ³ concrete/hr (1560 ft ³ /hr)	\$4.66/m ³ concrete (\$.13/ft ³)
Water Usage				
• High Wall	16 L/m ³ concrete (1.7 gal/ft ³)	\$0.53/kiloliter	132.5 L/m ³ concrete (14.2 gal/ft ³)	\$.53/kiloliter
• Slab at grade	1.1 L/m ³ (0.23 gal/ft ³)	\$2/thousand gallons	8.6 L/m ³ (1 gal/ft ³)	\$2/thousand gallons

The unit costs and production rates shown do not include mobilization, other losses associated with non-productive portions of the work (such as breaks), and wastewater treatment. The intention of this table is to show unit costs at their elemental level, free of site-specific factors (such as work culture or work environment influences on productivity loss factors). Consequently, the unit costs shown in the above table are the same unit costs for the corresponding line item in Table B-1 and Table B-2 of Appendix B. Table B-1 is a summary of the high-wall (Table B-1.1) and slab-at-grade (Table B-1.2) scenarios for the improved technology while Table B-2 is a summary of the high-wall (Table B-2.1) and slab-at-grade (Table B-2.2) scenarios for the baseline technology.

There are some features of the demonstration that affect cost, as follows:

- Work was performed in an uncontaminated area
- Wind was negligible
- Wastewater is treated at the Hanford Site Effluent Treatment Facility at a cost of \$0.066/L (\$0.25/gal), plus sampling and analysis at \$0.11/L (\$0.41/gal), plus tanker-truck transport at \$0.05/L (\$0.02/gal)
- Demolition of a high-wall would be done on different dates than a slab, and two mobilizations would be required.

■ Cost Conclusions

The mobilization and demolition costs are analyzed between the improved and baseline technologies in this comparison. Since the level of contamination requires a level D protection for both technologies, there are no PPE waste disposal costs involved. Wastewater capture and treatment costs have been excluded from this analysis. In addition, there are no demobilization costs allotted due to the demonstration condition that the equipment was not transported back to remote equipment yard. Refer to Appendix B of this report for detailed cost tables for the improved and baseline cost. The costs for the improved and the baseline technologies are summarized in Figure 3.

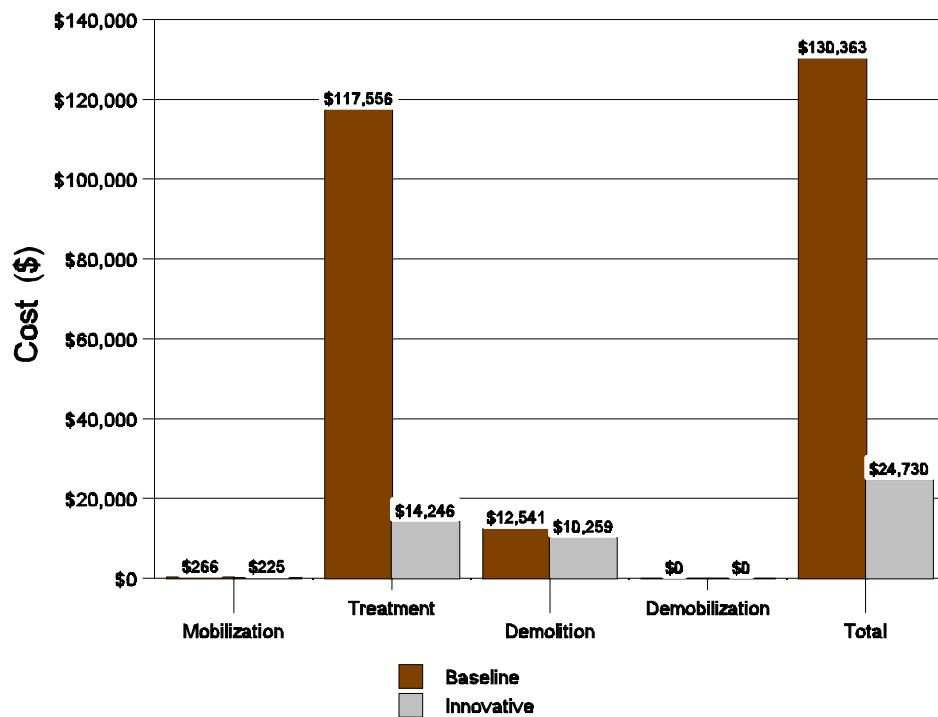


Figure 3. Cost summary.

Cost Drivers

The major cost drivers for the improved technology are wastewater treatment and labor during operation.

The comparison is dominated by a single parameter, wastewater treatment. For this estimate, a treatment cost of \$0.18/L (\$0.68/gal) was used. Depending upon the potential contaminants and the treatment options available, treatment costs may be negligible (in cases where disposal is by evaporation) or treatment costs may be higher than the rate used in this analysis. Where treatment costs are negligible, the improved technologies advantage over the baseline shrinks to approximately 18% less expensive.

By using spray nozzles that use a smaller amount of water than the fire hoses, the amount of water generated is reduced by 88% (20,950 gallons vs. 172,877 gallons for the baseline for concrete volumes shown in Table 3).

SECTION 6

REGULATORY/POLICY ISSUES

■ Regulatory Considerations

- The dust suppression system is a tool for controlling concrete dust generated by a demolition ram, and there are no special regulatory permits required for its operation and use.
- The system can be used in daily operation under the requirements of 10 CFR Parts 20 and 835, and proposed Part 834 for protection of workers and environment from radiological contaminants; and 29 CFR, OSHA worker requirements.
- Although the demonstration took place at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site, no CERCLA requirements apply to the technology demonstrated.

■ Safety, Risk, Benefits, and Community Reaction

Worker Safety

- Normal radiation protection worker safety procedures used at the facility would apply in contaminated areas. Unless field tests show that the operation of the dust suppression system operator is exposed to airborne particulates, respiratory protection is not required.

Community Safety

- It is not anticipated that implementation of the dust suppression technology would present any adverse impacts to community safety.

■ Environmental Impacts

- It is not anticipated that implementation of the dust suppression technology would present any adverse impacts to the environment, unless it used when wind speeds are too high.

■ Socioeconomic Impacts, and Community Perception

- No socioeconomic impacts are expected with the use of this technology.



SECTION 7

LESSONS LEARNED

■ Implementation

- No special implementation concerns apply to the dust suppression technology.

■ Technology Limitations/Needs for Future Development

- At the present time, there is no need to modify the system demonstrated at the Hanford Site C Reactor. Design modifications would be needed for applications of the system on different types of heavy equipment.
- While the improved technology provides acceptable dust control, wind in the demolition area blows water spray away from the dust-generating source. The amount of water required for dust suppression is somewhat inversely proportional to the wind speed. (Generally, construction activities stop at 32 km/hr (20 mph) wind speeds due to OSHA-imposed safety requirements.)

■ Technology Selection Considerations

- The technology is suitable for DOE nuclear facility D&D sites or similar sites where certain concrete structures must be demolished.



APPENDIX A

REFERENCES

10 CFR Part 835, "Occupational Radiation Protection," as amended.

Proposed 10 CFR Part 834, "Environmental Radiation Protection," as proposed.

10 CFR Part 20, "Occupational Radiation Protection," as amended.

29 CFR Part 1910, "General Industry Occupational Safety and Health Standards," as amended.

29 CFR Part 1926, "Construction Occupational Safety and Health Standards," as amended.

Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary, 1996, Headquarters United States Army Corps of Engineers, 20 Massachusetts Avenue, N.W., Washington, D.C., 20314-1000.



APPENDIX B

COST COMPARISON

■ Introduction

The cost effectiveness analysis computes the cost for operating a dust suppression system during a concrete demolition job by using hourly rates for equipment and labor.

The selected basic activities analyzed are from the Hazardous, Toxic, and Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary (HTRW RA WBS), USACE, 1996. The HTRW RA WBS, developed by an interagency group, provides consistency with established national standards.

Some costs are omitted from this analysis making it easier to understand and to facilitate comparison with costs for the individual site. The overhead and general and administrative (G&A) mark-up costs for the site contractor managing the demonstration are omitted from this analysis. Overhead and G&A rates for each DOE site vary in magnitude and in the way they are applied. Decision-makers seeking site-specific costs can apply their site's rates to this analysis without having to first back-out the rates used at the Hanford Site.

The following assumptions were used as the basis of the improved cost analysis:

- Oversight engineering, quality assurance, and administrative costs for the demonstration are not included. These are normally covered by another cost element, generally as an undistributed cost.
- The procurement cost of 7.5% was applied to all purchased equipment costs so that the costs of administering the purchase are accounted for (this cost is included in the hourly rate).
- The equipment hourly rates for the improved technology, Government's ownership option, are based on general guidance contained in Office of Management and Budget (OMB) circular No. A-94 for Cost Effectiveness Analysis. The amortized hourly rate accounts for hours/yr, years of life, the procurement adder, \$100/yr repair costs, and a discount rate of 5.8%.
- The equipment hourly rates for the site-owned equipment that may be used in support of field assembly of the improved equipment (for example the site-owned truck that transports the rented improved equipment from the receiving warehouse to the C Reactor) are standard equipment rates established at the Hanford Site. All supporting labor and equipment costs associated with the field assembly of the improved technology have been added to the \$17,415 fabrication cost and the sum amortized into an hourly equipment rate. These additional items are as follows:
 - ½ day of crane usage (\$28.46/hour) and a heavy-equipment operator (\$38.68/hour)
 - Two mechanics (\$50/hour each) and one truck (\$48/hour) for 40 hours each
 - One excavator crawler with hoe-ram for 40 hours (\$44.20/hour).
- The standard labor rates established by the Hanford Site for estimating D&D work are used in this analysis for the portions of the work performed by local crafts.
- The analysis uses an 8-hour work day.
- An anticipated life of 7 years for the dust suppression system at an average of 500 hours/year (that the excavator is reserved for concrete demolition work) is used in the calculation of an hourly rate for the improved technology.
- The equipment used in this demolition will stay at the C Reactor area and is not transported to the equipment storage facility.
- For the high-wall demolition, one full-time D&D worker is used for miscellaneous activities during the demolition, such as water tank refill, gasoline refills, and moving the scissor lift. The D&D worker is



accounted for a quarter of the time during low-wall demolition because of a high production rate and the absence of a scissor lift.

- Both the improved and baseline technologies have the same production rate for demolition activities. The production rate is for demolition time and does not include mobilization and other losses associated with non-production portions of the work.

MOBILIZATION (WBS 331.01)

Mobilize Equipment: The observed time required for transporting equipment to the work area, filling of water tanks and checking manlifts.

WASTEWATER TREATMENT (WBS 331.12)

Wastewater Treatment: Rates for onsite treatment of wastewater collected from the C Reactor are \$0.25/gal (based on conversations with the Effluent Treatment Facility operators). In addition to this, there are costs for transport to the treatment facility and sampling and analysis. The cost for transport includes tanker truck travel to C Reactor for pick-up, filling from the wastewater storage tank, travel to the treatment facility, and unload at the facility (2 hours travel for 1 teamster @ \$36.35/hr + 5000-gallon tanker truck @ \$15.52/hr = \$103.74 per tanker truck load or \$0.02/gal). Cost of sample collection and analysis is shown below for an assumed list of analytes:

Lab Analysis Costs	Sample Collection	Sample Transport
Metals Analysis \$205 Volatile Organics \$300 Semi-Volatile Organics \$550 Gross Beta (Total) \$50 Gross Alpha (Total) \$50 Uranium Isotopic \$137 Strontium \$100	2 sampler techs @ \$54.52/hr for 4 hrs (includes transport for shipping) = \$327/sample event	\$48 shipping

Total cost for the sample collection and analysis is \$1,766 plus 15% for sample management = \$2,031/sample event. Assuming one sample is collected per truck load, this would be a cost of \$0.41/gal. The total cost for treatment, transport, and sample analysis is \$0.68/gal.

DEMOLITION (WBS 331.17.04)

Safety Meeting: The baseline work required a safety meeting for each morning following the first day of work. The costs for the improved were assumed to be similar to the observed duration for the baseline.

Don and Doff PPE: This cost item includes time for each worker to fully suit-up in personal protective clothing (PPE) as well as material costs for the PPE, and includes removal of the PPE. The time spent donning and doffing each day is based on observed times for previous deployments (long term and large scale jobs). There are no material costs for daily PPE since the contamination PPE requirement for the test site was level D.

Operate Dust Suppression System during Concrete Demolition: This demonstration is based on the demolition of a 12.2-m-high x 0.9-m-thick x 30-m-long (40-ft x 3-ft x 100-ft) wall and a 9.1-m-high x 0.2-m-thick x 39.3-m-long (30-ft x 8-in. x 129-ft) water-tunnel roof slab. Water is sprayed directly on the dust generating source to minimize the dust cloud caused by the demolition activity. The production rate used is 9 m³/hour (317 ft³/hr), based on the production rate of the excavator.

Water Usage: This cost item includes the total gallons used during the demolition activities. A cost of \$0.53 per kiloliter (\$2 per 1000 gallon) is used.

DEMOBILIZATION (WBS 331.21)



Disassemble Equipment: The equipment remains on site and does not require disassembly.





**Table B-1. Cost summary - Auto Dust Suppression Improved System technology
(summary of high-wall and slab-at-grade scenarios)**

Work Breakdown Structure (WBS)	Unit	Unit Cost \$	Quantity	Total Cost \$	Computation of Unit Cost						Other Costs / and Comments	
					Prod. Rate	Duration (hr)	Labor & Equipment Rates					
							Labor Items	\$/hr	Equipment Items	\$/hr		
MOBILIZATION (WBS 331.01)			Subtotal	\$ 225								
Mobilize Equipment	LS	\$112.71	2	\$225		1	2DD	\$ 63.94	0.5SL+EC+0.5FH+0.5PG	\$48.77		
TREATMENT (WBS 331.12)			Subtotal	\$ 14,246								
Waste Water Treatment	gal	0.68	20949.6	\$ 14,246								
DEMOLITION (WBS 331.17.04)			Subtotal	\$ 10,259								
Safety Meeting	day	\$44.71	6	\$536		0.25	DD+OP+RCT	\$120.15	0.5SL+0.5FH+EC+0.5PG+DS	\$58.67		
Don & Doff Personal Protective Equipment (PPE)	day	\$0.00		\$0							Level D PPE.	
Operate Dust Suppression System during Concrete Demolition	CF	\$0.66	14,580	\$9,680	309.5		1.7DD+OP+RCT	\$142.53	0.97SL+DS+0.97FH+EC+0.97PG	\$62.97	Water spray can be turned on/off w/ foot or hand by equip. operator when needed. Scissor lift is used only during high wall demolition.	
Water Usage	gal	\$ 0.002	20949.6	\$42								
DEMOBILIZATION (WBS 331.21)			Subtotal	\$ 0								
None				\$0							Equipment stays on site	
TOTAL				\$ 24,730								
Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	
Field Supervisor	59.60	SU	Rigger	43.57	RG	Truck Tractor	11.71	TT	Truck (flat bed)	4.74	TK	
D&D Worker	31.97	DD	Scientist	65.18	SC	Low Boy Trailer	0.48	LB	Trailer (flat bed)	0.54	TR	
Teamster	36.35	TM	Lead Sampling Technician	54.77	LT	Gasoline-Powered Pump	2.49	PP	Excavator Crawler w/ hoe-ram	44.20	EC	
Heavy Equipment Operator	38.68	OP	Radiologic Control Technician	49.50	RCT	Skid-mounted Water Tank	23.97	WT	Auto Dust Suppression System	9.90	DS	
Fire Hose	0.02	FH	Plexiglass	0.05	PG	Scissor Lift	9.07	SL	Small Crane	28.46	CN	

Notes: 1. Unit Cost = (Labor +Equipment Rate) x Duration + Other Cost, or = ((Labor +Equipment Rate) / Productivity Rate) + Other Cost
2. Abbreviations for Units: LS = Lump Sum; gal = gallon; CF = cubic feet.



**Table B-1.1. Cost summary - Auto Dust Suppression System improved technology
(high-wall scenario)**

Work Breakdown Structure (WBS)	Unit	Unit Cost \$	Quantity	Total Cost \$	Computation of Unit Cost						Other Costs / and Comments
					Prod. Rate	Duration (hr)	Labor & Equipment Rates				
							Labor Items	\$/hr	Equipment Items	\$/hr	
MOBILIZATION (WBS 331.01) Subtotal				\$ 117							
Mobilize Equipment	LS	\$117.28	1	\$ 117		1.00	2DD	\$ 63.94	SL+EC+FH+PG	\$ 53.34	
TREATMENT (WBS 331.12) Subtotal				\$14,035							
Waste Water Treatment	gal	0.68	20640	\$ 14,035							
DEMOLITION (WBS 331.17.04) Subtotal				\$ 9,778							
Safety Meeting	day	\$51.84	6	\$311		0.25	1.75DD+OP+R CT	\$144.13	SL+EC+FH+PG+DS	\$63.24	1.5DD for SL and FH operation and 0.25DD for miscellaneous activities
Don & Doff Personal Protective Equipment (PPE)	day			\$0							Level D PPE.
Operate Dust Suppression Unit during Concrete Demolition	CF	\$0.79	12,000	\$9,426	264		1.75DD+OP+R CT	\$144.13	SL+EC+FH+PG+DS	\$63.24	Water spray can be turned on/off w/ foot or hand by equip. operator when needed. Scissor lift is used only during high wall demolition.
Water Usage	gal	\$ 0.002	20,640	\$ 41							
DEMOBILIZATION (WBS 331.21) Subtotal				\$ 0							
Disassemble Equipment	LS			\$0							Equipment stays on site.
TOTAL				\$ 23,931							
Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation
Field Supervisor	59.60	SU	Rigger	43.57	RG	Truck Tractor	11.71	TT	Truck (flat bed)	4.74	TK
D&D Worker	31.97	DD	Scientist	65.18	SC	Low Boy Trailer	0.48	LB	Trailer (flat bed)	0.54	TR
Teamster	36.35	TM	Lead Sampling Technician	54.77	LT	Gasoline-Powered Pump	2.49	PP	Excavator Crawler w/ hoe-ram	44.20	EC
Heavy Equipment Operator	38.68	OP	Radiologic Control Technician	49.50	RCT	Skid-mounted Water Tank	23.97	WT	Auto Dust Suppression System	9.90	DS
Firehose	0.02	FH	Plexiglass	0.05	PG	Scissor Lift	9.07	SL	Small Crane	28.46	CN

Notes:

1. Unit Cost = (Labor +Equipment Rate) x Duration + Other Cost, or = ((Labor +Equipment Rate) / Productivity Rate) + Other Cost
2. Abbreviations for Units: LS = Lump Sum; gal = gallon; CF = cubic feet.



**Table B-1.2. Cost summary - Auto Dust Suppression System improved technology
(slab-at-grade scenario)**

Work Breakdown Structure (WBS)	Unit	Unit Cost \$	Quantity	Total Cost \$	Computation of Unit Cost						Other Costs / and Comments	
					Prod. Rate	Duration (hr)	Labor & Equipment Rates					
							Labor Items	\$/hr	Equipment Items	\$/hr		
MOBILIZATION (WBS 331.01) Subtotal				\$108								
Mobilize Equipment	LS	\$108.14	1	\$108		1.00	2DD	\$ 63.94	EC	\$ 44.20		
TREATMENT (WBS 331.12) Subtotal				\$211								
Waste Water Treatment	gal	0.68	309.6	\$211								
DEMOLITION (WBS 331.1.047) Subtotal				\$475								
Safety Meeting	day	\$ 37.57	6	\$225		0.25	0.25DD+OP+RCT	\$ 96.17	EC+DS	\$ 54.10	0.25DD needed for filling water tank and other miscellaneous activities.	
Don & Doff Personal Protective Equipment (PPE)	day			\$0							Level D PPE.	
Operate Dust Suppression Unit during Concrete Demolition	CF	\$ 0.10	2,580	\$249	1560		0.25DD+OP+RCT	\$ 96.17	EC+DS	\$ 54.10		
Water Usage	gal	\$ 0.002	310	\$1								
DEMOBILIZATION (WBS 331.21) Subtotal				\$ 0								
Disassemble Equipment	LS			\$0							Equipment stays on site.	
TOTAL				\$793								
Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	
Field Supervisor	59.60	SU	Rigger	43.57	RG	Truck Tractor	11.71	TT	Truck (flat bed)	4.74	TK	
D&D Worker	31.97	DD	Scientist	65.18	SC	Low Boy Trailer	0.48	LB	Trailer (flat bed)	0.54	TR	
Teamster	36.35	TM	Lead Sampling Technician	54.77	LT	Gasoline-Powered Pump	2.49	PP	Excavator Crawler w/hoe-ram	44.20	EC	
Heavy Equipment Operator	38.68	OP	Radiologic Control Technician	49.50	RCT	Skid-mounted Water Tank	23.97	WT	Auto Dust Suppression System	9.9	DS	
Firehose	0.02	FH	Plexiglass	0.05	PG	Scissor Lift	9.07	SL	Small Crane	28.46	CN	

Notes: 1. Unit Cost = (Labor +Equipment Rate) x Duration + Other Cost, or = ((Labor +Equipment Rate) / Productivity Rate) + Other Cost
 2. Abbreviations for Units: LS = Lump Sum; gal = gallon; CF = cubic feet.



**Table B-2. Cost summary - Manual Dust Suppression baseline technology
(summary of slab-at-grade and high-wall scenarios)**

Work Breakdown Structure (WBS)	Unit	Unit Cost \$	Quantity	Total Cost \$	Computation of Unit Cost							Other Costs / and Comments	
					Prod. Rate	Duration (hr)	Labor & Equipment Rates						
							Labor Items	\$/hr	Equipment Items	\$/hr			
MOBILIZATION (WBS 331.01)			Subtotal	\$266									
Mobilize Equipment	LS	\$132.89	2	\$266		1.00	2DD	\$63.94	0.5PP+0.5TK+0.5WT+EC+PG+1.5FH+SL	\$68.95			
TREATMENT (WBS 331.12)			Subtotal	\$117,556									
Waste Water Treatment	gal	0.68	172877	\$117,556									
DEMOLITION (WBS 331.1.047)			Subtotal	\$12,210									
Safety Meeting	day	\$55.27	6	\$663		0.25	2DD+OP+RCT	\$152.12	0.5PP+0.5TK+0.5WT+EC+PG+1.5FH+SL	\$68.95			
Don & Doff Personal Protective Equipment (PPE)	day			\$0							Level D PPE.		
Operate Dust Suppression Unit during Concrete Demolition	CF	\$0.79	14,580	\$11,532	309.5		2.93DD+OP+RCT	\$181.85	0.035PP+0.035TK+0.035WT+EC+1.93PG+2.89FH+1.93SL	\$62.95	2 scissor lifts are used during high wall demolition. 1 scissor lift is needed for slab at grade demolition.		
Water Usage	gal	\$ 0.002	172877	\$346									
DEMOBILIZATION (WBS 331.21)			Subtotal	\$0									
Disassemble Equipment	LS			\$0							Equipment stays on site.		
TOTAL				\$130,363									
Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation		
Field Supervisor	59.60	SU	Rigger	43.57	RG	Truck Tractor	11.71	TT	Truck (flat bed)	4.74	TK		
D&D Worker	31.97	DD	Scientist	65.18	SC	Low Boy Trailer	0.48	LB	Trailer (flat bed)	0.54	TR		
Teamster	36.35	TM	Lead Sampling Technician	54.77	LT	Gasoline-Powered Pump	2.49	PP	Excavator Crawler w/ hoe-ram	44.20	EC		
Heavy Equipment Operator	38.68	OP	Radiologic Control Technician	49.50	RCT	Skid-mounted Water Tank	23.97	WT	Radiological Survey Equipment	1.38	RS		
Firehose	0.02	FH	Plexiglass	0.05	PG	Scissor Lift	9.07	SL	Small Crane	28.46	CN		

Notes: 1. Unit Cost = (Labor +Equipment Rate) x Duration + Other Cost, or = ((Labor +Equipment Rate) / Productivity Rate) + Other Cost

2. Abbreviations for Units: LS = Lump Sum; gal = gallon; CF = cubic feet.



**Table B-2.1. Cost summary - Manual Dust Suppression baseline technology
(high-wall scenario)**

Work Breakdown Structure (WBS)	Unit	Unit Cost \$	Quantity	Total Cost \$	Computation of Unit Cost						Other Costs / and Comments	
					Prod. Rate	Duration (hr)	Labor & Equipment Rates					
							Labor Items	\$/hr	Equipment Items	\$/hr		
MOBILIZATION (WBS 331.01) Subtotal				\$ 158								
Mobilize Equipment	LS	\$158.39	1	\$ 158		1.00	3DD	\$ 95.91	2SL+EC+2FH+2PG	\$ 62.48		
TREATMENT (WBS 331.12) Subtotal				\$115,872								
Waste Water Treatment	gal	0.68	170400	\$115,872								
DEMOLITION (WBS 331.17.04) Subtotal				\$ 11,918								
Safety Meeting	day	\$ 61.64	6	\$ 370		0.25	3DD+OP+RCT	\$ 184.09	2SL+EC+2FH+2PG	\$ 62.48		
Don & Doff Personal Protective Equipment (PPE)	day			\$0							Level D PPE.	
Operate Dust Suppression Unit during Concrete Demolition	CF	\$ 0.93	12,000	\$ 11,208	264		3DD+OP+RCT	\$ 184.09	2SL+EC+2FH+2PG	\$ 62.48		
Water Usage	gal	\$ 0.002	170,400	\$ 341								
DEMOBILIZATION (WBS 331.21) Subtotal				\$ 0								
Disassemble Equipment	LS			\$0							Equipment stays on site.	
TOTAL				\$127,949.0								
Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	Crew Item	Rate \$/hr	Abbreviation	
Field Supervisor	59.60	SU	Rigger	43.57	RG	Truck Tractor	11.71	TT	Truck (flat bed)	4.74	TK	
D&D Worker	31.97	DD	Scientist	65.18	SC	Low Boy Trailer	0.48	LB	Trailer (flat bed)	0.54	TR	
Teamster	36.35	TM	Lead Sampling Technician	54.77	LT	Gasoline-Powered Pump	2.49	PP	Excavator Crawler w/ hoe-ram	44.20	EC	
Heavy Equipment Operator	38.68	OP	Radiologic Control Technician	49.50	RCT	Skid-mounted Water Tank	23.97	WT	Radiological Survey Equipment	1.38	RS	
Firehose	0.02	FH	Plexiglass	0.05	PG	Scissor Lift	9.07	SL	Small Crane	28.46	CN	

Notes: 1. Unit Cost = (Labor +Equipment Rate) x Duration + Other Cost, or = ((Labor +Equipment Rate) / Productivity Rate) + Other Cost
2. Abbreviations for Units: LS = Lump Sum; gal = gallon; CF = cubic feet.

